FIRE-RESISTING COMPOSITE YARN WITH THREE TYPES OF FIBER

The invention concerns a fire resisting composite yarn and a textile comprising at least one woven or knitted textile layer formed with such a yarn.

The textile is typically intended for producing protective clothing, in particular clothing for the military or fire fighters or used in industry. In particular, the use of the textile is suited when the garment must confer a certain degree of thermal protection for a user.

For such applications, the yarn used must, when it is subjected to a flame or heat, have the following characteristics:

- resist fire, and in particular not be easily flammable;

- provide thermal insulation in order to protect the user from the heat;

- preserve a certain degree of mechanical cohesion so as to limit the formation of holes in the garment, which would lead to direct contact between the flame and the skin of the user;

- exhibit low thermal shrinkage so that the garment preserves its three-dimensional structure and therefore does not come into close contact with the skin of the user. This is because such a contact, becomes of the temperature of the garment, would give rise to a significant burns.

In addition, it is often desirable for the fabric to be able to be printed or coloured with a minimum degree of dichroism, in particular in a single phase, that is to say using a single printing or dying process.

This is because, in particular in military garments, this characteristic is particularly important because the quality of the colours printed or dyed has a direct influence on the quality of the camouflage conferred by the garment.

In addition, the yarn must have sufficient mechanical properties in terms of resistance to abrasion, toughness and stability, including colouring, during use or the various washings that the garment will have to undergo.

Finally the yarn proposed must have a production cost which is compatible with the applications in question.

The known yarns of the prior art do not fulfil all these constraints in an optimum fashion.

The invention therefore aims to remedy this drawback for proposing in particular a yarn composed of three types of fiber each having different properties and which, within a particular range of combinations, make it possible to obtain very satisfactory results over all the constraints mentioned above.

To this end, and according to a first aspect, the invention proposes a fire resistant composite yarn comprising:

- flame-retarded fibers in a quantity greater than 40% with respect to the total weight of the yarn, the said fibers being formed on the basis of a crystalline or semi-crystalline polymeric materials;

- hydrophilic fibers in a quantity of between 10% and 45% with respect to the weight of flame-retarded fibers, the said hyrdophilic fibers being formed by a non-fusible material;

- thermostable fibers in a quantity of between 4% and 50% with respect to the total weight of the yarn, the said thermostable fibers being formed by a non flammable material.

According to a second aspect, the invention proposes a textile intended for producing protective clothing, the said textile comprising at least one woven or knitted textile layer formed with such yarns.

Other objects and advantages of the invention will emerge during the following description.

The invention concerns a fire resistant composite yarn composed of three types of specific fiber, the said yarn being in particular able to be used for producing a textile for protective clothing, for example for the military, or for fire fighters or used in industry. This is because, in such applications, the constraints, in particular in terms of fire resistant and mechanical strength properties, are more and more severe so that there exists a significant demand for improving the known yarns, and this within a controlled cost.

According to a first type, the fibers are formed on the basis of a crystalline or semi-crystalline polymer material, that is to say typically having a degree of crystallinity greater than 25%.

In one example embodiment, the polymeric material is chosen from the group compring polyesters, polypropylenes and polyvinyl alcohols.

However, this type of material is not non-flammable as such. This is why, in order to obtain the fire resistant yarn, the fibers used must be flame retarded.

To this end, according to a first embodiment, the flame-retarded fibers comprise a flame-retarding polymeric material. In a particular example, the flame-retarding material may be a polyvinyl chloride which, during its combustion, releases a sufficient quantity of the chlorine to make the fiber non-flammable.

According to a second embodiment, the fibers can, subsequently to their manufacture, be surface treated with a known flame-retardant agent.

The flame-retarded fibers thus obtained therefore have, when they are subjected to a flame or significant source of heat, the dual property of not propagating flame and retarding the temperature rise in the yarn. This is because, because of their crystalline character, they have a fusion peak which makes it possible to absorb part of the thermal energy during their fusion. In order to obtain a composite yarn having satisfactory flame-retardant properties, the quantity of flame-retarded fibers used is greater than 40% with respect to the total weight of the yarn.

The problem which is posed with such flame-retarded fibers is that of their thermal stability. This is because the absorption of thermal energy is obtained by virtue of the partial fusion of the fibers, which gives rise to a deformation thereof.

To mitigate this drawback, the flame-retarded fibers are associated with a second type of fiber which is hydrophilic and formed by a non-fusible material.

Thus the second type of fiber makes it possible first of all to absorb part of the fusion energy of the flame-retarded fibers. This is because, because of their hydrophilic character, the fibers of the second type are able to absorb

energy by vaporisation of the stored water.

In addition, an improvement in the thermal stability of the combination of the first two types of fiber is obtained by virtue of the non-fusible character of the hydrophilic fibers. Thus the thermal shrinkage of the yarn is reduced so that the garment has a greater ability to preserve its three dimensional structure when it is exposed to a flame.

In addition, the hydrophilic fibers make it possible to obtain comfort in use, in particular with regard to the feel and the absorption of perspiration, which is advantageous.

The applicant carried out tests and found that these properties were advantageously obtained for a quantity of hydrophilic fibers of between 10% and 45% with respect to the weight of flame-retarded fibers. This is because, below this percentage, the contribution of the hydrophilic fibers is not sufficient in the context of the application in question, and below this percentage there are not enough flame-retarded fibers to effectively provide the anti-combustion and thermal energy absorption functions mentioned above.

The hydrophilic fibers can be produced on the basis of a natural or artificial cellulosic material such as cotton, viscose or rayon or based on wool.

In a variant, and in order to improve the flame retarded character of the yarn, the hydrophilic fibers can be treated so as to be at least partially flame retarded.

The yarn also comprises a third type of fiber which is thermostable and produced from a non-flammable material. Thermostable means fibers which preserve their physical properties at temperatures where the other fibers have lost them.

The function of the third type of fiber is in particular to reinforce, apart from the thermal properties, the mechanical properties of the yarn. In particular, the use of these fibers makes it possible to obtain resistance to abrasion, toughness and stability, in particular during use or various washings, which is compatible with the production of protective clothing. In addition, the thermostable fibers make it possible to limit the formation of holes in the fabric when the latter is subjected to a flame, and therefore to improve the fire-resistant protection conferred by the garment. In particular, the thermostable fibers also have an advantageous effect on the limitation of the thermal shrinkage of yarn.

The applicant carried out tests and found that the contribution of the thermostable fibers was advantageous as soon as they were present in a quantity equal to 4% with respect to the total weight of the yarn. This low percentage is particularly advantageous because first of all of the high cost of the thermostable fibers and secondly the possibility of printing them or dying them with simple techniques, in particular with the techniques conventionally used for the first two types of fiber. This constraint is particularly important in the military field because the quality of the colours printed or dyed has a direct influence on the quality of the camouflage conferred by the garment. And the low minimum percentage of thermostable fibers necessary in the yarn according to the invention also makes it possible to use thermostable fibers in which a specific colour is integrated which is arranged so as to merge in the colours applied subsequently to the fabric, without appreciably comparing the quality of the camouflage obtained.

In the case where a composite fiber with high mechanical

strength is required, it is also possible to integrate up to 50% of thermostable fibers with respect to the total weight of the yarn.

The thermostable fibers can be produced on the basis of a polymeric material chosen from the group comprising para-aramids, meta-aramids, polybenzimidazole-imides, polybenzooxazoles, polyacrylates, polyphenols, polyamide-imides, poly-p-phenylenediamine-terephthalamides (PPTA or M5).

According to a first embodiment, the fibers forming the yarn are mixed intimately by a conventional spinning technique. In this embodiment, the yarn can comprise between 4% and 20% thermostable fibers in order to optimise the ratio between the technical advantages conferred by these fibers compared with their cost and their colouring constraint.

In a particular example of a yarn according to this first embodiment of the invention, it is possible to cite a yarn formed from 72% by weight commercial PVA FR fibers (that is to say fibers formed on the base of polyvinyl alcohol and an inclusion of polyvinyl chloride), 23% by weight cotton and 5% by weight para-aramid fibers, which have fire-resistant characteristics (in terms of LOI (Limit Oxygen Index) that is to say in terms of a minimum concentration of oxygen necessary for causing ignition of the yarn in contact with a flame), mechanical strength and colouring capacity, which are particularly advantageous in the context of the applications in question. In particular, the yarn has an LOI defined according to ISO 4589-2 which is greater than 25%.

According to a second embodiment, the composite yarn comprises a core yarn formed with thermostable fibers and, associated around the said core yarn, a cladding formed from

an intimate mixture of the flame-retarded fibers and hydrophilic fibers. This type of yarn is conventionally produced by a technique of the core-spun type.

This embodiment corresponds conventionally to the case where a yarn with high tenacity is required so that the quantity of thermostable fibers can be fixed between 20% and 50% by weight of the yarn. In addition, the colouring constraints of the thermostable fibers are not posed because of the fact they are disposed in the core yarn.

The invention therefore proposes a particular combination of fibers which makes it possible to optimally fulfil in particular both the fire-resistant and mechanical constraints, and this within a cost compatible with industrial production.

In addition, the yarn according to the invention makes it possible to obtain a textile with sufficient flexibility to obtain an advantageous feel.

This is why the yarns according to the invention are in particular intended for producing a woven or knitted textile layer which is used in a textile for protective clothing.

As explained previously, the textile layer can advantageously be dyed or printed with a minimum degree of dichroism, in particular in a single phase, that is to say using a single colouring process, for example of the fixed washed type.

In addition, the textile can comprise, associated on the textile layer, an impermeable/breathable layer - that is to say impermeable to liquid water and to wind but permeable to water vapour - and non-flammable so as to confer this property on the protective garment made.

The impermeable/breathable layer can be produced in the form of a microporous and/or hydrophilic membrane or coating, for example made from polyurethane or polytetrafluoroethylene (PTFE), and be associated with the textile layer by screen-printing coating of a network of adhesive dots.